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ABSTRACT

Work continued on the revision of strands for the Drill-and-Practice Mathematics Program. Use of the system at schools in California, Kentucky, Mississippi, Washington, D.C., and at Tennessee A. and I. University was reviewed. Data analysis of all problems presented to California students was performed to determine possible areas for improvement. Progress in the Drill-and-Practice Reading Program involved efforts to make the curriculum machine-readable by recording audio messages in digitized form and development of a preprocessor program. A teacher's manual was prepared for the program. Eighty-five second-year computer-assisted instruction (CAI) Russian lessons have been completed, but delays in the implementation of the PDP-10 system slowed other progress. A preliminary instructional system for teaching programing languages was completed, consisting of a lesson coding language and a set of programs designed to interpret lesson material written in the lesson coding language. Curriculum development and implementation of the SIMPER and LOGO programs in CAI programing continued. Efforts were made to get the PDP-10 system operational and improve other equipment. The future plans for each of these projects are outlined. [Not available in hard copy due to marginal legibility of original document.] (JY)

PROGRESS REPORT

STANFORD PROGRAM IN COMPUTER-ASSISTED INSTRUCTION

for the period

JANUARY 1, 1969 to MARCH 31, 1969

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with Tennessee A. and I. State University

INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES
STANFORD UNIVERSITY
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I. Major Activities of the Reporting Period

A. Drill-and-practice Mathematics Program

1. Strand Program

Work continued on revision of the strands for grades 1 through 6. The decimal and fraction strands, which will continue through the eighth grade, were revised extensively to make a smooth transition from fifth- and sixth-grade work to the junior high school level. In addition, a new format was devised to introduce fraction problems in the second half of the third grade. As an example, a problem which fits the specifications of equivalence class 3.80 is reproduced here:

T T S T S S S

HOW MANY LETTERS ________.

__ / 7 OF THE LETTERS ARE T.

__ / 7 OF THE LETTERS ARE S.

3/7 + 4/7 = __ / 7 = ____.

The remaining strands (number concepts, equations, measurement, CAD laws, and negative numbers) for grades 7 and 8 were written. The seven strands which continue through grades 7 and 8 contain 190 equivalence classes distributed as shown in Table 1. The name of the counting strand has been changed to number concepts and will continue through the eighth grade. It includes problems on prime numbers, factors, multiples, exponents, scientific notation, and arithmetic in nondecimal base-number systems.

Ninth-grade algebra strand. During the quarter, two ninth-grade algebra books were selected to serve as guides for planning an algebra strand.[1] A problem count was started, and initial plans for the strand were formulated. The student response mode will be similar to that of the logic program in that students will learn a set of commands that can be used to instruct the computer to solve problems. A first draft of a set of commands sufficiently powerful to allow a student to solve most of the problems that commonly occur in ninth-grade algebra texts was devised. This initial set of commands is presented in Table 2.

Further work on the structure of the strand awaits the completion of the problem count.

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[1] Johnson, R. E. et al. Algebra. Palo Alto: Addison-Wesley, 1967. Dolciani, M. P. et al. Algebra I. Boston: Houghton Mifflin, 1967.

TABLE 1

Number of Equivalence Classes for Each Strand in Grades Seven and Eight

Strand name	Half-grade level 7.0	7.5	8.0	8.5	Totals
Number concepts	10	10	10	10	40
Equations	10	10	10	10	40
Fractions	5	5	5	5	20
Measurement	5	5	5	5	20
Decimals	5	5	5	5	20
CAD Laws	5	5	5	0	15
Negative numbers	10	10	10	5	35
Totals	50	50	50	40	190

TABLE 2

Commands for Algebra Strand

Let Q be any polynomial, k, m, line numbers.*

Commands for handling polynomial expressions

kF:Q	Factor Q in expression on line k.
kCT	Collect terms in expression on line k. This means perform any additions which are possible as the expression is written. (See further discussion below.)
kCC:Q	Cancel Q from numerator and denominator. (Note: this applies only when Q appears explicitly as a factor in both numerator and denominator. If Q does not, factoring must be done first.
kTA	Write as a single fraction for addition problem.
kTM	Write as a single fraction for multiplication problem.
kM	Carry out any possible multiplication.
kIV	Invert.
k(1,2,...t)(t+1,...z)	Insert parentheses in expression on line k so that first parenthesis contains first t terms, second parenthesis contains the remainder of the terms.
k(FR)	Enclose the numerator and denominator of each fraction on line k in parentheses.

Modifiers

nP	nP following any command restricts operation to the terms in the nth parenthesis.
nFR	nFR following any command restricts operation to the nth fraction on the line.
NUM	NUM following any command restricts operation to numerator.
DEN	DEN following any command restricts operation to denominator.

Commands for solving equations

kA:Q	Add Q to each member of equation shown in line k.
k.mA	Add line k to line m.
kS:Q	Subtract Q from each member of equation on line k.
k.mS	Subtract line k from line m.
kM:Q	Multiply by Q each member of equation shown on line k.
kM:Q/Q	Multiply numerator and denominator of fraction by Q.
A:	Student puts in answer.
End:	To signal computer to check previous line against correct answer.

Commands for algebra strand

kD:Q	Divide by Q each member of equation shown on line k.
SUBk.m	Substitute expression for variable on line k in its every occurrence on line m. (Note: This is a command to replace. No arithmetic is carried out without CT command.)
kSF	Instructs computer to type out Solution Format for quadratic equations.

*Note: In the commands given above, a single k may be omitted if it refers to the line immediately above.

2. Use of the System in Schools

The number of tests and lessons taken on the system at each school during this reporting period exceeded 92,381, which represents a gain of 9,374 lessons over last quarter, even though there were some system problems early in the period. Table 3 shows the number of lessons taken in each school or school area during each month of the reporting period. The number of lessons given each day in each area for each month is shown in Table 4. Table 4 also shows the daily totals for each school. Table 5 presents a list of the schools by identification number.

3. California Schools

A total of 31,971 lessons were given in Ravenswood schools and 10,575 lessons were given in other California schools. As indicated by the tables, difficulties that prevented students from taking daily lessons were overcome largely during this period. The Ravenswood project, in particular, began to operate smoothly on a regular daily basis. Temporary buildings that house the teletype terminals were completed and telephone lines were installed. Further, problems experienced at Stanford in the changeover from the PDP-1 to the PDP-10 system were solved by the end of the period.

4. Kentucky Schools

Approximately 8,400 lessons were given to Kentucky students during the period as shown in Tables 3 and 5. A combination of difficulties arising from telephone-line installation and inconsistent PDP-8 operation both at Kentucky and at Stanford accounted for the small number of students run this quarter. Those difficulties now have been solved and schools began to run on a daily basis. Some schools, however, still had not started by the end of the quarter.

5. Mississippi Schools

Mississippi students were given 28,337 lessons. Mississippi suffered difficulties similar to those of Kentucky, but to a lesser degree. Reports from Mississippi concerning student achievement continue to be positive. IMSSS CAI Newsletter, No. 1 (attached to this report) includes an account of Mississippi achievement gains in computational skills.

6. Tennessee A. and I. University

Few students ran near the end of the quarter owing to a variety of reasons; one was the normal break between quarters. Altogether 2,146 lessons were given to Tennessee A. and I. students.

TABLE 3

Monthly Distribution of Drills Run Per School
February, 1969

	3	4	5	6	7	10	12	13	17	18	19	20	21	24	25	26	27	28	RUNS PER SCHOOL
CALIF.																			
0	445	332	109	117	96	45	82	14	84	116	144	117	*	110	186	130	127	92	2346
1			150	150	136	49	*	0	0	0	0	0	*	0	86	0	0	0	571
2			35	34	40	5	*	0	0	0	0	0	*	0	0	0	0	0	114
3			89	87	91	0	*	0	0	0	0	0	*	0	76	0	0	0	343
4			42	0	0	27	*	0	0	0	0	0	*	0	0	0	0	0	69
5			58	50	62	18	*	0	0	0	0	0	*	0	29	0	0	0	217
6			10	5	5	0	4	0	0	0	0	0	*	0	0	0	0	0	24
BRENTWOOD																			
100	1497	1548	163	193	185	100	*	32	0	0	0	0	*	27	178	0	0	0	3923
101			408	479	467	178	*	0	0	0	0	0	*	60	349	0	0	0	1941
102			163	201	207	104	*	0	0	0	0	0	*	56	213	0	0	0	944
103			241	281	298	79	*	0	0	0	0	0	*	76	285	0	0	0	1260
104			230	190	205	112	*	0	0	0	0	0	*	66	185	0	0	0	988
105			96	99	96	50	*	0	0	0	0	0	*	0	99	0	0	0	440
106			213	225	230	77	*	0	0	0	0	0	*	58	273	0	0	0	1076
107			125	118	121	66	*	0	0	0	0	0	*	44	113	0	0	0	587
WASHINGTON																			
10	139	124	163	140	109	22	122	72	53	127	157	120	122	153	144	101	122	140	2130
OHIO																			
11			0	0	0	0	0	36	0	0	0	21	56	0	58	0	0	0	171
12			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IOWA																			
14			0	0	0	0	0	0	0	0	0	0	*	0	18	21	22	31	92
TENNESSEE																			
80	157	184	250	223	239	2	170	17	0	0	0	0	0	0	78	0	0	0	1320
MISSISSIPPI																			
20	1553	1600	129	152	88	1	73	0	0	0	0	30	0	0	86	0	0	0	3712
21			363	349	368	0	247	0	0	0	0	0	0	0	299	0	0	0	1626
22			24	28	29	2	27	0	0	0	0	0	0	0	0	0	0	0	110
23			155	154	172	0	77	0	0	0	0	0	0	0	143	0	0	0	701
24			144	144	148	4	68	0	0	0	0	0	0	0	101	0	0	0	609
25			151	125	129	6	86	0	0	0	0	0	0	0	105	0	0	0	602
26			79	49	13	2	9	0	0	0	0	0	0	0	35	0	0	0	187
27			337	340	301	0	175	0	0	0	0	0	0	0	253	0	0	0	1406
28			46	41	19	5	7	0	0	0	0	0	0	0	0	0	0	0	118
29			44	40	28	2	7	0	0	0	0	0	0	0	32	0	0	0	153
30			4	8	16	0	15	0	0	0	0	0	0	0	18	0	0	0	61
31			0	0	0	0	14	0	0	0	0	0	0	0	12	0	0	0	26
32			72	61	56	5	45	0	0	0	0	0	0	0	30	0	0	0	269
33			62	45	49	0	6	0	0	0	0	0	0	0	26	0	0	0	188
34			0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
KENTUCKY																			
40	383	335	34	32	29	0	4	154	0	0	0	0	0	0	16	0	0	0	987
41			67	82	93	20	46	0	0	0	0	0	0	3	47	0	0	0	358
42			7	0	12	0	15	0	0	0	0	0	0	0	3	0	0	0	37
43			36	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	53
44			23	25	18	0	2	0	0	0	0	0	0	0	3	0	0	0	71
45			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46			17	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58
47			0	0	34	0	14	0	0	0	0	0	0	0	0	0	0	0	48
48			68	74	63	0	2	0	0	0	0	0	0	0	15	0	0	0	222
49			0	0	0	0	1	0	0	0	0	0	0	0	29	0	0	0	30
50			49	72	87	0	0	0	0	0	0	0	0	0	38	0	0	0	246
51			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53			0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	18
54			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55			0	0	39	0	13	0	0	0	0	0	0	0	0	0	0	0	52
56			0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	14
57			0	0	15	0	0	0	0	0	0	0	0	0	9	0	0	0	24
58			32	48	41	0	0	0	0	0	0	0	0	0	0	0	0	0	121
59			2	3	0	14	0	0	0	0	0	0	0	0	1	0	0	0	20
60			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62			0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
63			26	0	0	32	21	0	0	0	0	0	0	4	33	0	0	0	116
64			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT.	4174	4123	4516	4506	4435	1027	1352	325	137	243	301	288	178	657	3757	252	271	263	30805

THE DISTRIBUTION FEATURE OF THE DRIVER STARTED 2-5-69.

ON 2-10-69 THERE WERE MORE RUNS THAN ACTUALLY SHOWN, DUE TO THE LOSS OF DISTRIBUTION AND TOTALS.

* SCHOOL HOLIDAY

NOTE:
THE PDP-10 SYSTEM & PDP-1 WAS DOWN ALL DAY 2-11-69 & 2-14-69
" " " WAS DOWN MOST OF 2-13-69 (NO DISTRIBUTION).
" " " " " ALL DAY 2-17-69 THRU 2-21-69
" " " " " ALL DAY 2-26-69 THRU 2-28-69

Table 3 (con't.)

Monthly Distribution of Drills Run Per School
March, 1969

	3	4	5	6	7	10	11	12	13	14	17	18	19	20	21	24	25	26	27	28	31	RUNS PER SCHOOL
CALIF.																						
0	112	109	8	53	106	173	193	180	155	153	68	164	107	167	85	110	212	235	319	167	95	2871
1	0	0	0	0	0	0	0	0	0	0	39	64	76	179	134	133	133	170	158	156	*	1242
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	12	30	38	*	130
3	0	0	0	0	0	0	0	0	0	0	0	35	29	70	68	47	87	98	96	103	*	633
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	44	0	0	*	68
5	0	0	0	0	0	0	0	0	0	0	20	29	17	36	43	56	65	59	52	26	*	403
6	0	0	0	0	0	0	0	0	0	0	2	0	6	6	0	1	3	0	1	6	*	25
BRENTWOOD																						
100	0	0	0	0	0	0	78	146	217	190	25	164	115	230	142	166	215	204	226	202	*	2320
101	0	0	0	0	0	0	0	0	0	0	159	289	236	417	463	379	435	447	473	479	*	3797
102	0	0	0	0	0	0	0	0	0	0	79	127	34	153	167	205	231	210	266	196	*	1668
103	0	0	0	0	0	0	0	0	0	0	77	146	153	221	125	167	221	153	145	167	*	1575
104	0	0	0	0	0	0	0	0	0	0	73	130	84	176	146	171	218	217	183	218	*	1616
105	0	0	0	0	0	0	0	0	0	0	73	74	72	130	124	122	127	136	145	147	*	1150
106	0	0	0	0	0	0	0	0	0	0	102	179	29	97	147	144	271	259	250	206	*	1684
107	0	0	0	0	0	0	0	0	0	0	16	77	83	137	118	132	141	137	147	134	*	1122
WASHINGTON																						
10	168	136	68	129	75	159	114	155	142	116	52	56	52	91	91	78	133	100	78	103	3	2059
OHIO																						
11	0	0	0	0	0	0	0	0	0	0	8	13	25	52	47	19	44	22	7	19	*	256
12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	11	26	46	43	45	*	184
13												3	2	0	0	3	47	63	69	58	*	245
IOWA																						
14	21	27	11	49	21	17	11	13	15	13	1	10	12	15	14	10	9	13	11	7	2	302
TENNESSEE																						
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	6	60	89	155
MISSISSIPPI																						
20	0	0	0	0	0	0	0	0	0	0	77	119	121	167	193	*	*	*	*	*	209	886
21	0	0	0	0	0	*	*	*	*	*	176	332	294	372	412	342	420	414	354	344	353	3813
22	0	0	0	0	0	0	0	0	0	0	*	16	24	27	28	13	*	*	*	*	0	108
23	0	0	0	0	0	0	0	0	0	0	48	110	101	137	157	173	198	227	171	187	136	1645
24	0	0	0	0	0	*	*	*	*	*	79	100	81	131	146	7	146	188	169	177	158	1382
25	0	0	0	0	0	*	*	*	*	*	48	106	92	149	55	147	291	232	222	258	187	1787
26	0	0	0	0	0	0	0	0	0	0	59	69	74	141	145	*	*	*	*	*	180	668
27	0	0	0	0	0	0	0	0	0	0	155	214	197	306	287	*	*	*	*	*	302	1461
28	0	0	0	0	0	*	*	*	*	*	7	21	26	19	4	56	89	39	69	43	38	411
29	0	0	0	0	0	*	*	*	*	*	4	14	5	0	0	*	57	45	36	38	51	250
30	0	0	0	0	0	*	*	*	*	*	0	0	0	0	0	*	*	*	*	21	29	50
31	0	0	0	0	0	0	0	0	0	0	12	25	27	34	41	*	*	*	*	*	29	168
32	0	0	0	0	0	*	*	*	*	*	22	45	15	55	64	24	71	59	62	35	0	452
33	0	0	0	0	0	0	0	0	0	0	6	6	37	28	27	*	*	*	*	*	35	139
34	0	0	0	0	0	*	*	*	*	*	15	20	9	23	0	0	12	58	30	21	19	207
KENTUCKY																						
40	0	0	0	0	0	0	0	0	0	0	0	9	1	16	31	8	31	7	21	11	19	154
41	0	0	0	0	0	0	0	0	0	0	26	31	2	17	14	35	27	37	79	80	79	427
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	0	0
43	0	0	0	0	0	0	0	0	0	0	9	32	12	22	41	9	32	20	13	65	27	282
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	31	0	0	0	32
46	0	0	0	0	0	0	0	0	0	0	10	18	8	0	0	2	42	43	44	39	0	206
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	0	0
48	0	0	0	0	0	0	0	0	0	0	7	9	19	24	50	35	49	57	53	28	40	371
49	0	0	0	0	0	0	0	0	0	0	33	52	40	66	55	46	75	66	56	38	55	582
50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	3
51	0	0	0	0	0	0	0	0	0	0	11	19	18	28	44	23	47	0	0	0	24	214
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	7	3	2	23	37	48	63	58	61	40	26	368
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	30	52
55	0	0	0	0	0	0	0	0	0	0	7	37	33	49	100	53	64	61	61	57	0	522
56	0	0	0	0	0	0	0	0	0	0	3	10	7	23	24	8	24	21	26	7	0	153
57	0	0	0	0	0	0	0	0	0	0	3	11	1	15	47	28	27	29	25	4	26	216
58	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	40	40	83
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	3	11
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	25	36	14	23	35	30	71	63	60	61	68	486
62	0	0	0	0	0	0	0	0	0	0	0	0	0	12	19	13	21	4	0	0	4	73
63	0	0	0	0	0	0	0	0	0	0	3	32	16		0	0	0	39	0	0	25	115
64	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	7	12	13	25	15	0	77
65	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	1	1
66	0	0	0	0	0	0	0	0	0	0	0	0	0	5	21	*	*	*	*	*	0	26
67	0	0	0	0	0	0	0	0	0	0	1	29	28	14	64	26	72	91	100	68	68	561
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT.	299	274	87	231	202	329	396	474	509	452	1647	3027	2437	4109	4067	3113	4631	4547	4444	4222	2450	41947

* SCHOOL HOLIDAY

NOTE:
THE PDP-10 SYSTEM WAS DOWN FROM 3-3-69 THRU 3-14-69.

TABLE 4

Monthly Distribution of Drills Run Per Area

	California	Iowa	Kentucky	Mississippi	Ohio	Ravenswood	Tennessee	Washington	Total
January									
6	22	0	0	0	0	0	0	24	46
7	0	0	0	0	0	129	0	0	129
8	4	0	0	21	0	143	0	100	268
9	4	0	0	47	0	252	0	100	403
10	0	0	130	114	0	0	0	2	246
15	24	0	27	284	0	296	113	0	744
16	36	0	25	190	0	265	25	115	656
17	187	0	133	749	0	659	23	143	1,894
20	202	0	0	0	0	326	0	0	528
21	0	0	0	0	0	0	0	0	1,837
22	0	0	0	0	0	0	0	0	1,658
24	0	0	0	0	0	0	0	0	1,204
28	0	0	0	16	0	0	0	65	81
29	316	0	211	1,441	0	1,247	103	122	3,439
30	400	0	197	1,552	0	1,418	216	94	3,877
31	300	0	183	726	0	1,145	191	74	2,619
Total	1,495		906	5,140		5,880	671	839	19,629
February									
3	445	0	383	1,553	0	1,497	157	139	4,174
4	332	0	335	1,600	0	1,548	184	124	4,123
5	493	0	361	1,610	0	1,639	250	163	4,516
6	443	0	377	1,537	0	1,786	223	140	4,506
7	430	0	431	1,417	0	1,809	239	109	4,435
10	144	0	66	27	0	766	2	22	1,027
11	PDP	DOWN				PDP	DOWN		
12	86	0	118	856	0	0	170	122	1,352
13	14	0	154	0	36	32	17	72	325
14	PDP	DOWN				PDP	DOWN		
17	84	0	PDP DOWN	0	0	0	0	53	137
18	116	0	PDP DOWN	0	0	0	0	127	243
19	144	0	PDP DOWN	0	0	0	0	157	301
20	117	0	PDP DOWN	30	21	0	0	120	288
21	0	0	PDP DOWN	0	56	0	0	122	178
24	110	0	7	0	0	387	0	153	657
25	377	18	247	1,140	58	1,695	78	144	3,757
26	130	21	PDP DOWN	0	0	0	0	101	252
27	27	22	PDP DOWN	0	0	0	0	122	271
28	92	31	PDP DOWN	0	0	0	0	140	263
Total	3,684	92	2,479	9,770	171	11,159	1,320	2,130	30,805
March									
3	112	21	PDP	DOWN	0	0	0	166	299
4	109	27	PDP	DOWN	0	0	0	138	274
5	8	11	PDP	DOWN	0	0	0	68	87
6	53	49	PDP	DOWN	0	0	0	129	231
7	106	21	PDP	DOWN	0	0	0	75	202
10	173	17	PDP	DOWN	0	0	0	139	329
11	193	11	PDP	DOWN	0	78	0	114	396
12	180	13	PDP	DOWN	0	146	0	135	474
13	135	15	PDP	DOWN	0	217	0	142	509
14	133	13	PDP	DOWN	0	190	0	116	452
17	129	1	145	708	8	604	0	52	1,647
18	232	10	330	1,197	16	1,186	0	56	3,027
19	235	12	202	1,103	27	806	0	52	2,437
20	458	15	342	1,589	53	1,561	0	91	4,109
21	330	14	582	1,559	59	1,432	0	91	4,067
24	371	10	373	762	33	1,486	0	78	3,113
25	550	9	679	1,284	117	1,859	0	133	4,631
26	618	13	640	1,262	131	1,783	0	100	4,547
27	656	11	626	1,113	119	1,835	6	78	4,444
28	496	7	561	1,124	122	1,749	60	103	4,222
31	95	2	535	1,726	0	0	89	3	2,450
Total	5,372	302	5,015	13,427	685	14,932	155	2,059	41,947

TABLE 5

Project Schools with Identification Numbers

0	= Lab and Demos
1	= Walter Hays School, Palo Alto, California
2	= Fremont Hills School, Los Altos Hills, California
3	= Oak Knoll School, Menlo Park, California
4	= Jordan Junior High School, Palo Alto, California
5	= Peter Burnett Junior High School, San Jose, California
6	= Dave Voorhees, Special Accounts
10	= Gallaudet College, Washington, D.C.
11	= Chapelfield Elementary School, Gahanna, Ohio
12	= Avery Elementary School, Hilliard, Ohio
13	= Prairie Lincoln School, Columbus, Ohio
14	= Job Corps Center, Clinton, Iowa
20	= Universal School, McComb, Mississippi
21	= Otken School, McComb, Mississippi
22	= Alpha Center, McComb, Mississippi
23	= Kennedy Elementary School, McComb, Mississippi
24	= Netterville Elementary School, McComb, Mississippi
25	= Summit Elementary School, McComb, Mississippi
26	= Taggart School, McComb, Mississippi
27	= Westbrook Elementary School, McComb, Mississippi
28	= Franklin Attendance Center, Meadville, Mississippi
29	= Magnolia Elementary School, Magnolia, Mississippi
30	= Fernwood Elementary School, Magnolia, Mississippi
31	= Lillie Mae Bryant High School, Meadville, Mississippi
32	= Denman Junior High School, McComb, Mississippi
33	= Eva Gordon School, McComb, Mississippi
34	= Terminal Vocation School, McComb, Mississippi
40	= University Breckinridge School, Morehead, Kentucky
41	= Elliottville Grade School, Elliottville, Kentucky
42	= Paintsville Elementary School, Paintsville, Kentucky
43	= Upper Tygart School, Olive Hill, Kentucky
44	= Sandy Hook Elementary School, Sandy Hook, Kentucky
45	= Pikeville City School, Pikeville, Kentucky
46	= Louisa Elementary School, Louisa, Kentucky
47	= Flat Gap School, Flat Gap, Johnson County, Kentucky
48	= Holy Family Elementary School, Ashland, Kentucky
49	= Pine Acres Elementary School, Ashland, Kentucky
50	= Cannonsburg Elementary School, Catlettsburg, Kentucky
51	= Mayslick Elementary School, Maysville, Kentucky
52	= Menifee County Elementary School, Frenchburg, Kentucky
53	= Worthington Elementary School, Worthington, Kentucky
54	= Woodleigh Elementary School, Maysville, Kentucky
55	= Greysbranch Elementary School, Greenup, Kentucky
56	= Greenup Elementary School, Greenup, Kentucky
57	= Oakview Elementary School, Ashland, Kentucky
58	= Salyersville Grade School, Salyersville, Kentucky
59	= Adult Education, L. B. Johnson School, Jackson, Kentucky
60	= Hatfield School, Catlettsburg, Kentucky
61	= Fox Valley Elementary School, Wallingford, Kentucky
62	= Inez Grade School, Inez, Kentucky
63	= Prestonsburg Elementary School, Prestonsburg, Floyd City, Kentucky
64	= Owingsville Elementary School, Owingsville, Kentucky
65	= Deming Elementary School, Mt. Olivet, Kentucky
66	= Lewis County Elementary School, Vanceburg, Kentucky
67	= Russell Central School, Russell, Kentucky
68	= Germantown Elementary School, Germantown, Kentucky
80	= Tennessee A. & I. State University, Nashville, Tennessee
100	= Belle Haven School, East Palo Alto, California
101	= Brentwood School, East Palo Alto, California
102	= Costano School, East Palo Alto, California
103	= James Flood School, East Palo Alto, California
104	= Kavanaugh School, East Palo Alto, California
105	= O'Connor School, East Palo Alto, California
106	= Runnymede School, East Palo Alto, California
107	= Willow School, East Palo Alto, California

7. Washington, D. C.

Approximately 5,028 lessons were given to the deaf students at Kendall School in Washington, D. C. There were only three terminals at the school, but students averaged more lessons per teletype terminal than at any other school.

8. Other Schools

Single terminals were installed in Franklin County Schools in Ohio and the Job Corps Center at Clinton, Iowa. The Ohio terminal is effectively three terminals; however, only one is in operation at any given time. The three cooperating schools divide the lesson time among themselves, so that a larger number of students can be involved.

Table 6 presents the number of classes and students in each class assigned to each grade level in each area.

9. Data Analysis

All problems presented to California students during 1967-68 were classified according to the strand and equivalence class defined in the new strand program. After classification, the average proportion correct for all problems in a given class and strand was calculated for each grade in which the problems were presented. These data were then used to determine possible changes in the ordering and definitions of the equivalence classes.

The revised vertical addition strand with the proportion correct for each equivalence class at each grade level is shown in Table 7. One example of a change resulting from the data is the reordering of classes 3.50 and 3.60. Originally the two-row three-column problems with one regrouping (3.60) appeared in the strand as class 3.45 with the three-row two-column problems with no regrouping (3.50) not appearing until class 3.70. The data indicated that the three-row problems were easier than expected, and the order of the two classes was reversed. Also, the difficulty of the regrouping problem warranted placement at a later point in the curriculum, i.e., from 3.45 to 3.60.

The data in Table 7 also indicate that performance on a given problem type does not necessarily improve as students progress in grade level. Although the proportion correct increases across grades for some problems, e.g., from .65 in grade 2 to .86 in grade 5 for class 2.50, for other problems, e.g., those in classes 1.10, 2.10, 2.65, 3.15, 4.45, and 4.50, the proportion correct either remained relatively constant over all grades or increased from the first to the second year in which the problems were presented and then remained constant.

TABLE 6

Number of Classes and Students*

	School	1	2	3	4	5	6	7	8	9
0	Lab and Demos	(1,7)	(1,4)	(1,9)	(1,4)	(1,14)	(1,9)	(1,10)		
1	Walter Hays Elementary				(3,59)	(3,85)	(5,103)			
2	Fremont Hills Elementary			(2,30)						
3	Oak Knoll Elementary	(1,24)	(2,38)	(4,48)			(1,13)			
4	Jordan Junior High							(1,20)	(4,47)	
5	Peter Burnett Junior High								(1,15)	(9,77)
6	Dave Voorhees, Special Accts.	(1,9)	(1,10)	(1,9)	(1,10)	(1,9)	(1,9)			
10	Gallaudet College	(1,25)	(1,36)	(1,20)	(2,60)	(1,7)	(2,43)			
11	Chapelfield Elementary		(1,8)				(3,32)			
12	Avery Elementary				(3,31)					
13	Prairie Lincoln Elementary			(1,17)	(1,15)					
	Mississippi Schools									
20	Universal School	(2,46)	(2,51)	(2,52)	(2,48)	(2,59)	(1,34)			
21	Otken School	(3,79)	(3,77)	(3,93)	(3,91)	(3,87)	(3,94)			
22	Alpha Center	(1,28)	(1,17)							
23	Kennedy Elementary	(2,42)	(1,36)	(1,35)	(1,30)	(1,30)	(1,34)			
24	Netterville Elementary	(1,32)	(1,33)	(1,27)	(2,45)	(1,25)	(1,31)			
25	Summit Elementary	(1,28)	(1,33)	(1,30)	(1,31)	(1,26)	(1,29)			
26	Taggart Elementary	(2,51)	(2,49)	(1,40)	(1,39)	(2,54)	(1,29)			
27	Westbrook Elementary	(2,44)	(4,125)	(3,90)	(3,91)	(3,97)	(3,85)			
28	Franklin Attendance Center					(1,36)	(2,70)			
29	Magnolia Elementary			(2,68)						
30	Fernwood Elementary					(1,35)				
31	Lillie Mae Bryant High School									(1,28)
32	Denman Junior High School									(4,94)
33	Eva Gordon School				(1,35)		(1,36)			
34	Terminal Vocation School			(1,27)						
	Kentucky									
40	University Breckinridge School	(1,24)	(1,18)	(1,19)	(1,20)	(1,18)	(1,16)			
41	Elliottville Grade School	(1,22)	(2,14)	(2,20)	(2,34)	(1,21)	(1,4)			
42	Paintsville Elementary				(3,45)					
43	Upper Tygart School		(1,21)			(2,34)	(4,30)			
44	Sandy Hook Elementary			(2,30)		(1,34)				
45	Pikeville City School					(1,31)	(1,33)			
46	Louisa Elementary		(1,25)	(1,27)	(1,18)	(2,22)				
47	Flat Gap School			(2,33)	(1,18)	(1,18)				
48	Holy Family Elementary						(1,21)		(1,18)	(1,19)
49	Pine Acres Elementary	(1,2)			(1,26)	(1,3)				
50	Cannonsburg Elementary	(1,2)	(1,4)	(1,2)	(1,3)	(1,7)	(3,62)			
51	Mayslick Elementary		(1,40)	(1,28)						
52	Menifee County Elementary						(2,42)			
53	Worthington Elementary					(1,3)	(1,39)			
54	Woodleigh Elementary					(2,69)				
55	Greysbranch Elementary			(1,37)	(1,33)					
56	Greenup Elementary					(1,35)				
57	Oakview Elementary					(2,57)				
58	Salyersville Grade School	(1,13)	(1,13)	(1,10)	(1,10)	(1,9)	(1,25)			
59	Adult Education-L. B. Johnson			(1,11)	(1,19)	(1,10)	(3,47)			
60	Hatfield School							(1,21)		
61	Fox Valley Elementary	(1,10)	(2,46)				(1,38)			
62	Inez Grade School					(1,32)	(1,32)			
63	Prestonsburg Elementary		(2,12)	(3,5[illegible])	(3,63)	(1,9)	(3,86)			
64	Owingsville Elementary						(1,29)	(1,29)		
65	Deming Elementary		(1,17)		(1,12)		(1,39)			
66	Lewis County Elementary					(2,66)	(2,52)			
67	Russell Central School				(1,18)	(1,12)	(1,6)			
68	Germantown Elementary					(1,2)	(2,51)			
80	Tennessee A. & I. State Univ.		(1,1)					(1,1)		Gr 13 (6,109)
	Ravenswood, California	K	1	2	3	4	5	6		
100	Belle Haven School	(1,12)		(3,83)	(8,118)	(1,15)	(7,99)	(1,19)		
101	Brentwood School	(2,62)	(7,172)	(7,193)	(4,97)		(3,79)	(1,37)		
102	Costano School			(7,150)		(2,28)	(7,98)	(7,76)		
103	James Flood School			(2,42)	(2,29)	(4,36)	(3,63)	(3,50)		
104	Kavanaugh School			(10,148)		(4,131)				
105	O'Connor School	(2,54)		(3,24)	(4,48)	(3,43)	(1,11)	(1,18)		
106	Runnymede School			(5,68)	(4,52)	(5,64)	(1,2)	(2,54)		
107	Willow School		(4,56)	(1,19)	(2,35)	(7,64)				

*In each entry, number of classes given first, then number of students.

TABLE 7

Average Proportion Correct for Each Equivalence Class -

Vertical Addition Strand

Equivalence class	Definition		Grade 1	2	3	4	5	6
1.00	a + b	$a + b \leq 4$	.93 (24)*	.99 (2)				
1.10	a + b a + a	$5 \leq a + b \leq 9$ one addend 0 or 1 $5 < 2a < 9$	.93 (21)	.82 (7)	.98 (2)	.97 (2)		
1.20	a + b	$5 \leq a + b \leq 9$ $a > 1,\ b > 1,\ a \neq b$	.88 (14)	.96 (8)		.94 (1)		
1.30	a + b	$8 \leq a + b \leq 9$ $a > 1,\ b > 1,\ a \neq b$	.85 (12)	.92 (18)	.97 (2)			
1.40	a b + c	$a + b + c \leq 9$			.93 (2)			
1.50	1 0 + a		100 (1)	.94 (1)				
1.60	a 0 + b 0	$a + b \leq 9$						
1.70	a 0 + c	$a > 1$						
1.80	a 0 b 0 + c 0	$a + b + c \leq 9$						
1.90	a b c + d	$a + b + c + d \leq 9$						

TABLE 7 (con't)

Equivalence class	Definition	Grade 1	2	3	4	5	6
2.00	$\begin{array}{r} a \\ +\ a \\ \hline \end{array}$ $10 \leq 2a \leq 18$		.48 (2)				
2.10	$\begin{array}{r} a \\ +\ b \\ \hline \end{array}$ $10 \leq a + b \leq 14$, $a \neq b$	.74 (3)	.53 (25)	.51 (5)	.50 (2)		
2.20	$\begin{array}{r} a \\ +\ b \\ \hline \end{array}$ $15 \leq a + b \leq 17$			.60 (3)	.57 (1)		
2.30	$\begin{array}{r} 10 \\ 10 \\ 10 \\ +\ c \\ \hline \end{array}$ $\begin{array}{r} 10 \\ 10 \\ +\ c \\ \hline \end{array}$						
2.40	$\begin{array}{r} a0 \\ +\ b0 \\ \hline \end{array}$ $a + b > 9$						
2.50	$\begin{array}{r} a\ b \\ +\ c \\ \hline \end{array}$ $b + c \leq 9$		.65 (2)	.78 (10)	.87 (11)	.86 (2)	
2.55	$\begin{array}{r} c \\ +\ a\ b \\ \hline \end{array}$ $b + c \leq 9$		.61 (2)	.80 (6)		.75 (2)	
2.60	$\begin{array}{r} a0 \\ c0 \\ +\ e \\ \hline \end{array}$ $\begin{array}{r} a0 \\ e \\ +\ c0 \\ \hline \end{array}$ $\begin{array}{r} e \\ a0 \\ +\ c0 \\ \hline \end{array}$ $a + c \leq 9$						
2.65	$\begin{array}{r} a\ b \\ +\ c\ d \\ \hline \end{array}$ $b + d \leq 9$, $a + c \leq 9$			.88 (14)	.94 (18)	.90 (4)	.90 (4)
2.70	$\begin{array}{r} a\ b\ c \\ +\ d \\ \hline \end{array}$ $c + d \leq 9$						
2.75	$\begin{array}{r} a00 \\ b0 \\ +\ c \\ \hline \end{array}$						

TABLE 7 (cont'd)

Equivalence class	Definition		Grade 1	2	3	4	5	6
2.80	a b + c	b + c > 9 a < 9			.82 (8)	.74 (8)	.78 (3)	
2.85	a b + c	10 ≤ a + b + c ≤ 14 a + b ≤ 9						
2.90	c + a b	b + c > 9 a < 9			.86 (4)		.87 (2)	
2.95	a b + c	15 ≤ a + b + c ≤ 19			.70 (2)			
3.00	a0 b0 + c0	10 ≤ a + b + c ≤ 19						
3.05	a b c / + d e f a b c / + e f b c / + d e f c + f ≤ 9, b + e ≤ 9, a + d ≤ 9				.92 (12)	.92 (10)		
3.10	a b + c d	b + d ≤ 9 a + c > 9						
3.15	a b + c d	b + d > 9 a + c ≤ 8			.82 (10)	.86 (4)	.82 (2)	.81 (1)
3.20	a b c + d	c + d > 9						
3.25	a b + c d	b + d > 9 a + c > 8				.47 (2)		

TABLE 7 (cont'd)

Equivalence class	Definition	Grade 1	2	3	4	5	6
3.30	$\begin{array}{r} a \\ b \\ +\ c \\ \hline \end{array}$ $20 \leq a + b + c \leq 27$						
3.35	$\begin{array}{r} a\ b\ c \\ +\ d\ e\ f \\ \hline \end{array}$ $c + f \leq 9,\ b + e \leq 9$; $a + d > 9$						
3.40	$\begin{array}{r} a \\ b \\ c \\ +\ d \\ \hline \end{array}$ $10 \leq a + b + c + d \leq 20$						
3.45	$\begin{array}{r} a\ b\ c \\ +\ d\ e\ f \\ \hline \end{array}$ $\begin{array}{r} a\ b\ c \\ +\quad e\ f \\ \hline \end{array}$ $\begin{array}{r} b\ c \\ +\ d\ e\ f \\ \hline \end{array}$ $c + f \leq 9,\ b + e > 9$; $a + d < 9$					.82 (6)	
3.50	$\begin{array}{r} a\ b \\ c\ d \\ +\ e\ f \\ \hline \end{array}$ $b + d + f \leq 9$; $a + c + e \leq 9$			.90 (10)			.90 (1)
3.60	$\begin{array}{r} a\ b\ c \\ +\ d\ e\ f \\ \hline \end{array}$ $\begin{array}{r} a\ b\ c \\ +\quad e\ f \\ \hline \end{array}$ $\begin{array}{r} b\ c \\ +\ d\ e\ f \\ \hline \end{array}$ $c + f > 9,\ b + e < 9$; $a + d \leq 9$			.75 (10)	.68 (2)		.82 (4)
3.70	$\begin{array}{r} 1\ a \\ b \\ +\ c \\ \hline \end{array}$ $\begin{array}{r} a \\ 1\ b \\ +\quad c \\ \hline \end{array}$ $\begin{array}{r} a \\ b \\ +\ 1\ c \\ \hline \end{array}$ $a + b > 9$				.39 (1)		

TABLE 7 (cont'd)

Equivalence class	Definition	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
3.80	$\begin{array}{r} a\,b\,c\,d \\ +\,e\,f\,g\,h \\ \hline \end{array}$ $\begin{array}{r} a\,b\,c\,d \\ +\,\,f\,g\,h \\ \hline \end{array}$ $\begin{array}{r} b\,c\,d \\ +\,e\,f\,g\,h \\ \hline \end{array}$ $d + h \leq 9$, $c + g \leq 9$ $b + f \leq 9$. $a + e \leq 9$						
3.90	$\begin{array}{r} a\,b \\ c\,d \\ +\,e\,f \\ \hline \end{array}$ $b + d + f \leq 9$ $a + c + e > 9$						
4.00	$\begin{array}{r} a \\ b \\ c \\ +\,d \\ \hline \end{array}$ $a + b + c + d \geq 20$						
4.05	$\begin{array}{r} a\,b\,c\,d \\ +\,e\,f\,g\,h \\ \hline \end{array}$ $d + h \leq 9$, $c + g \leq 9$ $b + f \leq 9$, $a + e > 9$						
4.10	$\begin{array}{r} a\,b \\ c\,d \\ +\,e\,f \\ \hline \end{array}$ $b + d + f > 9$ $a + c + e \leq 7$			.48 (2)			
4.15	$\begin{array}{r} a\,b \\ c\,d \\ e\,f \\ +\,g\,h \\ \hline \end{array}$ $\begin{array}{r} a\,b \\ d \\ e\,f \\ +\,g\,h \\ \hline \end{array}$ $\begin{array}{r} b \\ c\,d \\ e\,f \\ +\,\,h \\ \hline \end{array}$ $\begin{array}{r} a\,b \\ d \\ f \\ +\,g\,h \\ \hline \end{array}$ $\begin{array}{r} a\,b \\ c\,d \\ e\,f \\ +\,\,h \\ \hline \end{array}$ $\begin{array}{r} a\,b \\ d \\ e\,f \\ +\,\,h \\ \hline \end{array}$ $b + d + f + h \leq 9$ $a + c + e + g \leq 9$						
4.20	$\begin{array}{r} a\,b\,c\,d \\ +\,e\,f\,g\,h \\ \hline \end{array}$ $\begin{array}{r} a\,b\,c\,d \\ +\,\,f\,g\,h \\ \hline \end{array}$ $\begin{array}{r} b\,c\,d \\ +\,e\,f\,g\,h \\ \hline \end{array}$ $a + e \leq 9$ and $d + h > 9$, $c + g < 8$, $b + f < 9$ or $d + h \leq 9$. $c + g > 9$, $b + f < 8$ or $d + h \leq 9$, $c + g \leq 9$, $b + f > 9$						

TABLE 7 (cont'd)

Equivalence class	Definition	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
4.25	a b c d e f + g h i $c + f + i \leq 9$ $b + e + h \leq 9$ $a + d + g \leq 9$						
4.30	a b c / + d e f ; a b c / + e f ; b c / + d e f $c + f > 9$, $b + e > 9$ $a + d < 9$			.58 (7)	.69 (6)	.71 (2)	.80 (2)
4.35	a b c d / + e f g h ; a b c d / + f g h ; b c d / + e f g h $a + e \leq 9$ and $d + h > 9$, $c + g > 9$, $b + f < 9$ or $d + h > 9$, $c + g < 9$, $b + f > 9$ or $d + h \leq 9$, $c + g > 9$, $b + f > 9$			.67 (7)	.76 (1)		.74 (2)
4.40	a b c / + d e f $c + f \leq 9$, $b + e > 9$, $a + e > 8$ or $c + f > 9$, $b + e < 9$, $a + e > 9$ or $c + f > 9$, $b + e > 9$, $a + e > 8$			.38 (3)	.72 (1)		
4.45	a b c d / + e f g h ; a b c d / + f g h ; b c d / + e f g h $d + h > 9$, $c + g > 8$, $b + f > 8$, $a + e < 9$			.70 (6)	.70 (7)	.72 (1)	
4.50	a b c d / + e f g h $d + h > 9$, $c + g > 8$, $b + f < 9$, $a + e > 9$ or $d + h > 9$, $c + g < 9$, $b + f > 9$, $a + e > 8$ or $d + h \leq 9$, $c + g > 9$, $b + f > 8$, $a + e > 8$ or $d + h > 9$, $c + g > 8$, $b + f > 8$, $a + e > 8$			.68 (2)	.67 (5)	.68 (1)	.64 (2)

TABLE 7 (cont'd)

Equivalence class	Definition	Grade 1	2	3	4	5	6
4.60	a b c d + e f $b + d + f > 9$ $a + c + e > 8$			.48 (14)			
4.70	a b c d e f + g h i $c + f + i > 9, b + e + f \leq 8, a + d + g \leq 9$ or $c + f + i \leq 9, b + e + f > 9, a + d + g \leq 8$ or $c + f + i \leq 9, b + e + f \leq 9, a + d + g > 9$						
4.80	a b c d e f + g h $b + d + f + h \leq 9$ $a + c + e + g > 9$						.55 (1)
4.90	b c / d e f / + g h i; a b c / e f / + g h i; a b c / d e f / + h i $c + f + i > 9, b + e + h > 9$						
5.00	a b c d e f + g h $b + d + f + h > 9$ $a + c + e + g > 8$						
5.10	a b c d e f + g h i $c + f + i > 9, b + e + h \leq 8, a + d + g > 9$ or $c + f + i \leq 9, b + e + h > 9, a + d + g > 8$ or $c + f + i > 9, b + e + h > 8, a + d + g > 8$						

TABLE 7 (cont'd)

Equivalence class	Definition	Grade 1	2	3	4	5	6
5.20	a b c d e / + f g h i b c d e / + a f g h i $a < 9$ and $e + i > 9, d + h > 8, c + g > 8$ or $e + i > 9, d + h > 8, b + f > 9$ or $e + i > 9, c + g > 9, b + f > 8$ or $d + h > 9, c + g > 8, b + f > 8$						
5.30	a b c / d e f / g h / + i j a b c / e f / d g h / + i j a b c / e f / g h / + d i j b c / a e f / d g h / + i j b c / a e f / g h / + d i j b c / e f / a g h / + d i j $c + f + h + j > 9, b + e + g + i > 8,$ $a + d \leq 8$						
5.40	a b c d e / + f g h i j $e + j > 9, d + i > 8, c + h > 8$ $b + g > 8, a + f \leq 8$						
5.50	Same as 5.30 except $a + d > 8$						
5.60	a b c d e / + f g h i j $e + j > 9, d + i > 8, c + h > 8,$ $b + g > 8, a + f > 8$						
5.70	a b c d / e f g h / + j k l a b c d / f g h / + e j k l $d + h + l > 9, c + g + k > 8,$ $b + f + j > 8, a + e \leq 8$						

TABLE 7 (cont'd)

Equivalence class	Definition		Grade 1	2	3	4	5	6
5.80	a b c d e f g h i + j k l	$c + f + i + l > 9$ $b + e + h + k > 8$						
5.90	a b c d e f g h + i j k l	$d + h + l > 9$, $c + g + k > 8$, $b + f + j \geq 8$, $a + e + i > 8$						

*Number of problems.

B. Drill-and-practice Reading Program

1. Curriculum

As of March 31, the CAI reading curriculum, completed through Strand 4, was successfully operating with digitized audio on Ravenswood City School District teletypes, although it had not yet been assigned on a class-schedule basis.

Owing to delivery delays of lower-case keytops for the reading teletypes and the delivery of faulty typewheels, the staff decided to operate the reading program by using the IMSSS standard typewheel and keyboard which involved minor, temporary adjustments in the reading curriculum.

The major progress during this reporting period involved efforts by the staff to make the CAI reading curriculum machine-readable by (a) recording audio messages and preparing a directory, and (b) writing, debugging and executing a preprocessor program.

The first 1,000 audio messages are now stored in digitized form, and can be printed, edited, and assembled for use with the preprocessor. The directory contains numbers that identify audio words and messages. Experiments with individual recording and the storage of audio messages directly onto the IBM 2314 disk indicated excessive time requirements; therefore, tapes of the first 1,000 messages were recorded with a tone behind each word or word part. As the tape was processed through the program that deposits the digitized audio messages on the disk, the tone signals when storage is to begin and end.

The preprocessor program transforms the original curriculum text, (input by hand) into blocks of digits that represent (a) the sequence number of the problem, (b) the number of characters in each item, (c) the teletype code followed by the audio number for each item, and (d) in the case of the phonic strand, the audio numbers and teletype code for the exemplar words. The processed file can be altered and up-dated on-line, but must be processed in turn for actual program use to allow the binary machine code to be stored on the 2314 disk.

2. Digitized Audio

Digitized audio refers to a complex conversion process unlike the familiar reproduction of sound via phonograph or tape recorder. These latter mechanisms are analog devices, i.e., devices that store and reproduce continuous information. Digital computers handle discrete units of information. Speech waves are analog (continuous) information and must be converted to digital form for storage by digital computers and reconverted to analog form for reproduction.

The analog-digital conversion for storage is performed by sampling the speech wave, i.e., breaking it up (chopping it) into a series of digits that indicate whether the wave is higher or lower at given points. Analog-digital conversion is presently done in two stages. The original speech wave can either be live or tape recorded--the Stanford project works from a master tape for convenience, First, a program receives the original wave filtered through a band pass that selects only certain sound frequencies (500-2,500) to adapt the sound wave to telephone-line conditions. This program samples (chops up) the wave 6,000 times a second, assigning a digit between 0 and 63 to each sample (i.e., 6-bit resolution). A second program takes this temporarily stored output and samples 36,000 times a second, assigning either 1 or 0 (up or down)--i.e., 1-bit resolution at 36kc. This final digital output is stored on an IBM disk (the digital equivalent of a phonograph record).

The digital-analog conversion process takes place during run time, i.e., as students run on the system. The call for a given audio message by the instructional program directs the computer to bring the appropriate block of digital information from the 2314 disk to one of the 2k (2,048-computer-word) audio buffers in core memory. From core the digits are fed to the multiplexer, which assigns them to one of 40 station shift registers that control the 40 audio units at student terminals. Before leaving Stanford via individual telephone lines, these audio digits pass through DAC's (digital-to-analog converters). A two-part amplification system at each of the eight schools picks up the analog information and feeds it to the headset at each terminal. One amplifier, adjustable by proctors, controls minimum volume for all terminals, while terminal amplifiers can be adjusted by individual students.

Figure 1 indicates the major steps in the process described above.

3. Teacher's Manual

A manual was prepared by the reading staff for use by teachers and proctors. Its purpose is to acquaint the reader with the CAI reading curriculum, terminal procedures, and materials unique to the reading program.

Chapter I presents a brief introduction to computers and tells of their limitations and capabilities, and the efforts made by IMSSS to apply the unique capabilities of computers to the processes of education.

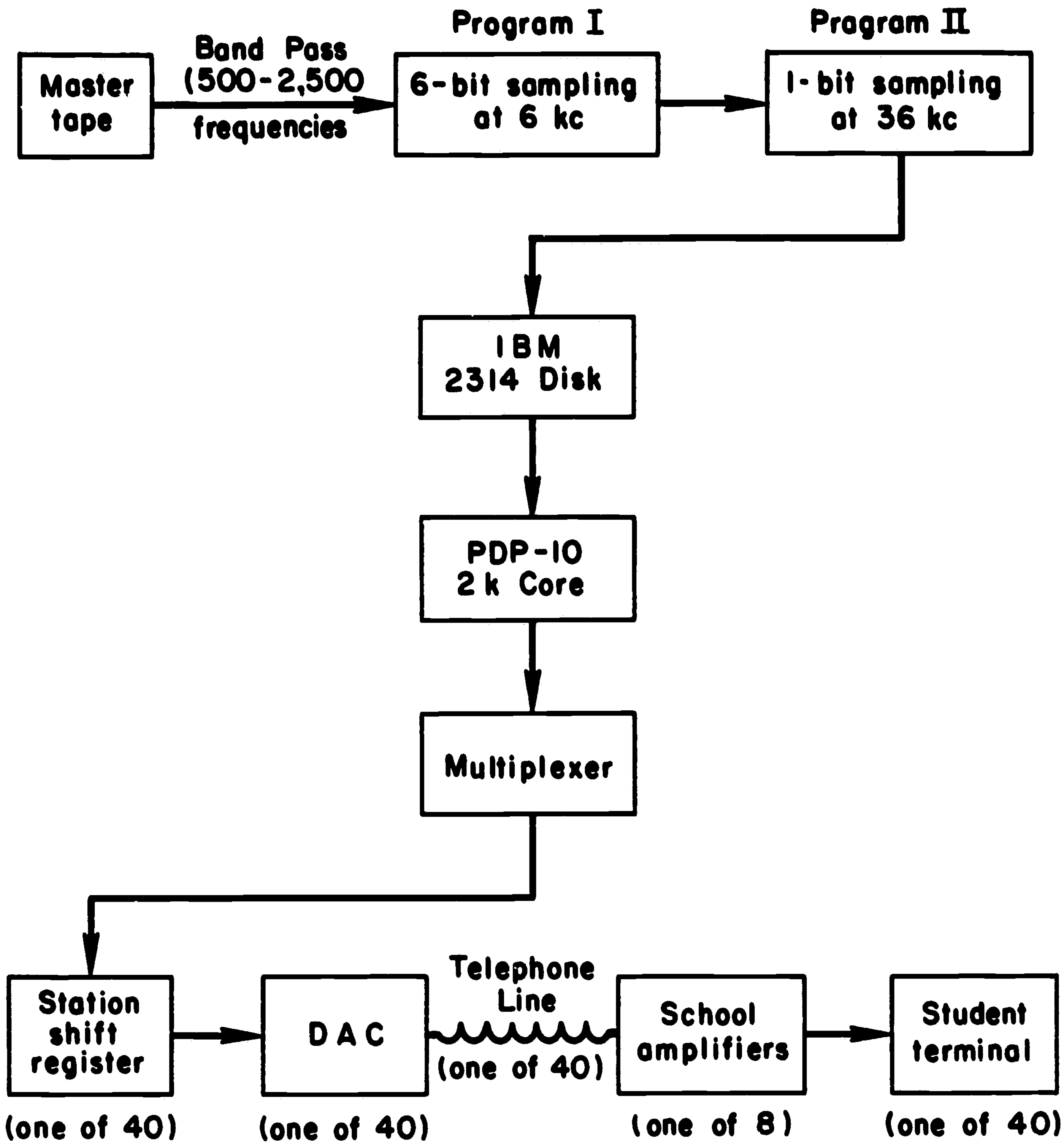

Fig. 1. Diagram of Analog-digital-analog Process, CAI Reading Program.

Chapter II gives the rationale for the development of the computer-based curriculum in initial reading, establishing the basis for the program's emphasis on regular grapheme-phoneme correspondences.

Chapter III provides an overview of the curriculum of the CAI initial reading program, the format of the five-strand structure of the basic reading skills and examples of the exercises used within each strand. The intent to have the program assist the teacher as a teaching tool is explained in the teacher's report.

Chapter IV introduces the reader to the operational aspects of instructional terminals, such as keeping the teletype machines supplied with ribbon and paper, and checking the audio volume.

Chapter V is a glossary of selected terminology used in the manual that assists the reader with the computer-age vernacular.

4. Systems

The reading curriculum passed through three stages:

1. Development of a prototype reading program written for the PDP-1 system that would drive a single student terminal through the reading curriculum.
2. Translation of this prototype to PDP-10 assembly language as soon as the PDP-10 became available.
3. Interfacing the PDP-10 program with the generalized "drill-driver" program which would enable the basic prototype to drive many student terminals through the curriculum on a time-shared basis.

During this last quarter, the translation of the PDP-1 prototype for assembly on the PDP-10 system was debugged and completed. The interfacing or meshing of the reading program was completed and the reading curriculum now runs as a portion of the Stanford PDP-10 drill-driver package.

Work is proceeding to provide support programs for efficient analysis and retrieval of reading student data and for facile manipulation of reading student parameters and restart information for experimental purposes.

C. Second-year Russian Program

1. Curriculum

Eighty-five second-year Russian lessons, including review lessons, have been completed and entered into the computer. Homework and study sheets were prepared for Lessons 1 through 85 and were distributed to the students. The homework followed the pattern established during the first quarter.

During this period the students read approximately twenty pages from Anton Chekhov, Selected Short Stories, Oxford, 1964. A sentence-by-sentence (in certain instances, clause-by-clause) translation of this material was entered into the computer. At the beginning of each computer-based session a student who had difficulties with a given part of the text could obtain a translation thereof by specifying the page and line number at which the sentence or clause began.

Because of the delays in the implementation of the PDP-10 system, little progress was made in the development of new programs.

The computer-based assistance in reading, which was found to be ineffective because of the student's inability to assess his own understanding of a passage, was abandoned.

Because of the delays in the implementation of a satisfactory PDP-10 system, work on computer-based audio, individualized remedial sessions, and data analysis were delayed. Programs written for the PDP-10 are now being debugged. New programs are being written for the data analysis on PDP-1 system, but progress in the other areas depends on the availability of the PDP-10.

2. Data Analysis

Gathering of data continued as in the first quarter. The implementation of the analysis was hindered seriously by the lack of a reliable PDP-10 system during most of this period.

Fifty per cent of the content of the final examination for the winter quarter was identical for the computer-based and for the regular sections. Table 8 shows the results of the examination. The groups were not significantly different (Mann-Whitney $U = 78.5$, $p > .10$). While the average number of errors was slightly less for the regular group than for the computer-based group, it should be borne in mind that the enrollment for the regular section decreased from 11 to 8 students during the winter quarter, while only 1 of 19 students was lost in the computer-based section. Since the students who left the regular and computer-based sections were not in the upper half of their class, the regular group at the end of the second quarter represents a more select group (72.7 per cent) in terms of the original enrollment than does the computer-based group (94.9 per cent).

TABLE 8

Common Portion of Final Examination of the Second Quarter

Total Possible Errors - 200			
Computer-based class		Conventional class	
Errors	Students	Errors	Students
13	1	11	1
$14\frac{1}{2}$	3		
16	1	16	1
$16\frac{1}{2}$	1	..	
		17	2
$18\frac{1}{2}$	2		
21	1		
		22	1
$22\frac{1}{2}$	1		
23	1		
$23\frac{1}{2}$	1	$23\frac{1}{2}$	1
24	1		
25	1		
		$26\frac{1}{2}$	1
$27\frac{1}{2}$	1	$27\frac{1}{2}$	1
$33\frac{1}{2}$	1		
$35\frac{1}{2}$	1		
$38\frac{1}{2}$	1		
Total errors	400.0	Total errors	160.5
Total students	18	Total students	8
Average number of errors	22.2	Average number of errors	20.1

D. Computer-assisted Instruction in Programming: AID

1. The Preliminary Instructional System

The first major achievement of the current reporting period was the completion of a preliminary instructional system for teaching programming languages.[2] The teaching system consists of a lesson coding language and a set of programs designed to interpret lesson material written in the lesson coding language. The system presents lessons to students by means of a standard teletype connected by telephone lines to a PDP-1 computer located at the Computer-based Laboratory, Stanford University.

The lesson preprocessor. The preliminary instructional system, completed in January, 1969, is composed of two main programs, a lesson preprocessor and a lesson driver. The lesson preprocessor transforms lesson code (lessons written in the specially designed coding language) into binary code that can be interpreted by the lesson driver. The preprocessor is an off-line program, that is, it is not in action at the times students are taking lessons; all preprocessing takes place before the lesson driver is called into action. Once the preprocessor has been used, there exists a permanent file of lessons in binary code which can be used by the lesson driver at any time. In the preliminary stages of curriculum development many changes must be made in lessons, either minor changes in wording of problems, or insertions, deletions, and reorderings of entire lessons. The preprocessor was designed to make such changes efficiently without requiring re-processing of entire lesson files. The main task of the lesson preprocessor, besides transforming lesson code into binary code, is to prepare a problem directory that gives the location of each problem in the problem file, so that the lesson driver can assess any problem rapidly with a minimum of serial scanning of the lesson file. The lesson preprocessor also allows the coder to insert standard messages for correct-answer responses, wrong-answer responses, requests for hints, and requests for a display of a correct answer. These messages can be changed easily at any time, and any changes made by the coder can be put into effect immediately for all preceding, as well as following, lessons.

The lesson preprocessor was written as a self-instructional program, since it was presumed that lesson coding and preprocessing would be done by relatively inexperienced personnel. (This conforms to one of the main requirements for the

[2]For a description of the goals of the project and requirements of the instructional system, see the Quarterly Progress Report for October-December, 1968.

coding language: that the language be sufficiently simple to be usable by almost untrained writers and coders.)

The lesson preprocessor was written in the assembly language of the PDP-1 computer, using the PASS assembler, and requiring about 2k of core when in operation. The program is operated from one of the Philco consoles in use at the Computer-based Laboratory and is a regular-user program, running under the system time-sharing monitor. The entire preprocessing system is actually a two-stage processor; the first stage is the PASS assembler itself. Most syntax errors in the coding are detected by the first stage, and this method of error analysis has been found quite satisfactory. To date, the only coding errors that have remained undetected by the preprocessor have been errors in text strings (spelling, punctuation, etc.), and purely semantic errors (unintentional use of incorrect op codes, etc.) which should not in any case be detected by a preprocessor. In addition, there is a possibility of losing an entire problem if the coder states that a lesson contains 17 problems and he actually codes 18. The eighteenth problem would be processed and put on the lesson file, but since it is not entered into the problem directory, the lesson driver cannot assess it. The possibility of losing a problem in this way is so unlikely and so easily corrected that there are no current plans for improving the preprocessor.

The lesson driver. The second major component of the teaching system is the program which presents the lessons to the students by using teletypes as student stations. This program is known as the "lesson driver."

The lesson driver has two faces, the one it presents to the operator and the one it presents to the student. From the viewpoint of the operator, working at a Philco console, the program is essentially self-instructional (the "operator's manual" consists of a single page of instructions) and allows the operator to register new students, delete student names from the registry, or to attach any teletype to the lesson driver.

Once the program is in operation at a teletype, it is completely independent and requires no further service from the operator until time to log out the system. The program allows any registered student to sign on and continue the lessons from whatever problem he was last working on. When the student signs off, the program automatically prepares itself for the next student and continues in operation with one student after another until the program is logged out by the operator.

From the viewpoint of the student, the lesson driver is considerably more complex. Any registered student is allowed to sign on by typing his student number when requested. He may then continue the lessons from the last problem of his last session or he may start with any problem he specifies. As soon as a student specifies a problem number (or indicates a desire to continue in sequence), the lesson driver consults the problem directory of the lesson file to locate the binary code for the desired problem. The text of the problem statements is translated into character code appropriate to a teletype and the problem statement is displayed. The program pauses, awaiting a response from the student. The student has several options: he may make a response to the problem by typing his answer and then a terminating character, he may request a hint by typing a specified control character, he may request a display of the correct answer (another specified control character), he may require the program to skip the problem and to present the next problem in sequence, or he may require the program to branch to an entirely different problem.

If the student responds to a problem by typing an answer followed by a terminating character, the program immediately analyzes his response to determine whether it corresponds to one of the correct answers (as supplied by the coder). If the response is correct, the correct-answer message is typed and the next problem is presented. If the response is incorrect, the wrong-answer message is typed and the program awaits another student response. There is no time limit on the problems, and there is no limit to the number of allowable incorrect responses; the student simply keeps working until he produces a correct answer, or until he requeststhe program to tell him the answer, or to skip the problem.

The lesson driver allows as much freedom of choice to the student as possible. The student is free to do problems in any sequence, going back to review previous problems if desired, or skipping ahead for a preview of coming lessons. The preliminary version of the lesson driver does not keep student histories, however; the only information that is saved by the program is the student's number and the number of the last problem he was doing.

Since coding errors are unavoidable, the lesson driver was designed to compensate for errors in the code whenever possible. Standard messages are used whenever the coder omits special messages; for example, if the coder fails to supply a hint for a problem, the program types "NO HINT WAS WRITTEN" if a student requestsa hint for that problem. Other kinds of coding errors are usually

detected by the lesson preprocessor when the lesson code is processed. Any errors that remain uncorrected are compensated for by the lesson driver; if a coding error is encountered while a student is using the program, the message "THERE IS AN ERROR IN THIS PROGRAM. SKIPPING TO NEXT PROBLEM." is typed for the student and the lesson driver assesses the next problem in sequence. To date, this default routine has not been used during student operation, since the errors were found and corrected during the lesson debugging process.

The lesson driver program is written in the assembly language of the PDP-1 computer and uses 5k of core during operation. The program is initiated by an operator using any one of the Philco consoles at the Computer-based Laboratory and is a regular user program, running under the system time-sharing monitor. The program can operate any of the standard Model-33 or Model-35 teletypes which are attached to the PDP-1. The response time of the program has not been accurately measured, but is within reasonable bounds; the average response time is well within 1 second and no response time of more than 3 seconds has yet been observed (the program has been closely observed through more than 50 hours of operation). The program was completed in January and no program bugs have been found since then.[3]

The coding language. The development of a suitable coding language has been one of the major objectives of the project. The main requirements of a coding language are that it be concise, easy to learn, and powerful enough to allow the curriculum writer to require analyses of student responses in as much detail as desired. The preliminary version of the coding language consists of 10 op codes, 4 pseudo op codes, and text strings. The mnemonics for the op codes were chosen to be as brief, yet self-explanatory, as possible; for example, the op code PROB is used to indicate the text string for the problem statement, the op code EQNUM indicates that the student response is expected to be a number equal to the number in the text string following the code word EQNUM.

The syntax of the coding language is quite simple, especially insofar as text strings are concerned; each character in a text string stands for itself, allowing the coder to type text in the code exactly as he wishes it to appear on the student's teletype.

The language has been completely defined and described in a 30-page Coders' Reference Manual, which was completed during the current reporting period.

[3]There are several features of the lesson driver which could be improved, although they are not, technically, bugs. Desired changes will be discussed in a future report.

The lesson code is entered into computer storage by means of the text editing program, TVEDIT, a PDP-1 user program in operation at the Computer-based Laboratory. Lessons are stored on disk files until processed. After processing (by means of the lesson preprocessor described above) the processed code is added to a disk file which contains code for the entire course; this processed lesson file, which is used by the lesson driver program, currently contains about 100,000 words (18-bit computer words). After processing, the original lesson code is no longer needed and is stored on DEC tape (magnetic tape) as a permanent record.

2. The Curriculum for AID

The bulk of lesson writing, coding, and debugging was postponed until the programs for the preliminary instructional system were completely written and debugged. Production of lessons began in earnest by February 1, 1969, and by the end of March, 30 lessons had been written and 15 of those coded and debugged. The average lesson contains 21 problems. There are about 3,000 words (18-bit words) of coding per lesson, which is reduced to 1,500 words by the preprocessor.

As anticipated, some changes in the course outlines became necessary as writing progressed.[4] Although the changes are minor, the revised outline of the first 30 lessons is reproduced here for reference (see Table 9).

The course is to be supplemented by two manuals, a Student Manual and an AID Programmers' Reference Manual. The Student Manual will contain an outline of the programmed lessons, and a list of assignments for the students. Each assignment consists of two to six problems or reading references to be completed by the student soon after taking the corresponding programmed lesson (there is one assignment per lesson). Work on the Student Manual is done in conjunction with the writing of programmed lessons; the manual now is complete through Lesson 30. Most of the reading assignments given in the Student Manual refer to the AID Programmers' Reference Manual published by Digital Equipment Corporation, Maynard, Massachusetts.

3. Student Use of Program

A small number of students have started taking the computer-assisted instruction in AID programming. Observation of student reactions will supply information to help the writer in revising lessons and in writing specifications for a final (time-sharing) version of the instructional program.

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[4]The initial proposed outline can be found in the Progress Report for the period July 1, 1968 to September 30, 1968.

TABLE 9

Outline of Lessons 1 to 30

Computer-assisted Instruction in Programming: AID

Lesson	Description
1	How to answer. How to erase. Control commands.
2	Arithmetic operators: +, -, *, / Decimal numbers. The TYPE command. Signing on and off AID.
3	Order of arithmetic operations. The operator ↑ for exponentiation. Scientific notation.
4	Variables. The SET command. The multiple TYPE command.
5	Formulas. The LET command. The TYPE FORMULA command.
6	The AID functions IP(X), FP(X), SGN(X), and SQRT(X).
7	Indirect steps. Parts. DO STEP... DO PART... The DELETE command.
8	IF clauses. Relation symbols: <, >, <=, >=, =, # .
9	AND, OR, and NOT used in IF clauses.
10	Branching. The TO command. TO STEP... TO PART...
11	The indirect use of DO. The DEMAND command.
12	Self-test.
13	Summary and Review.
14	The FORM statement. TYPE "..." TYPE ← .
15	How to write a program.
16	How to debug a program. Traces.
17	Loops.
18	Loops with variable upper bound.
19	More about loops.
20	The FOR clause.
21	Comparison of loops and FOR clauses.
22	More about DEMAND.
23	Self-test.
24	Summary and review.
25	Absolute value. ¦X¦
26	Optional lesson. SIN(X). COS(X).
27	Optional lesson, EXP(X). LOG(X).
28	Lists of numbers.
29	More on lists.
30	More on lists and loops.
31	SUM, PROD, MAX, MIN.
32	Matrices.

This pilot study is not intended to be a rigidly controlled experiment in any sense, and there will be no detailed report written on student use, although excerpts from the anecdotal Weekly Log of Student Activities will be given in the next quarterly report.

E. Computer-assisted Instruction in Programming: SIMPER and LOGO

1. Curriculum

The 38 SIMPER lessons to be used this school year were written and coded. Table 10 gives an outline of the lessons. In addition, the first 20 lessons were revised on the basis of comments made by the teachers working in the classroom at Woodrow Wilson High School. A homework assignment for each lesson was also prepared. These assignments were prepared on dittoed sheets, but were coded so the student could check each assignment on-line. Tests and extra-credit problems were also written and coded.

The student's manual was completed and duplicated. Each manual contains the following items: (a) a description of the teaching program; (b) a discussion of grading for the course; (c) signing on and off the teaching program; (d) use of the control commands; (e) use of the choice point; (f) a description of SIMPER; (g) a description of LOGO; (h) an outline of lessons; (i) a discussion of homework, tests, and extra-credit problems; (j) a glossary; and (k) a list of special symbols and characters.

The teacher's manual was also completed and duplicated. Each contains the following items: (a) the student manual; (b) a copy of each homework assignment; (c) a copy of extra-credit problems; (d) discussion of possible student problems; (e) description of informative messages supplied by either the teaching program or SIMPER (those from LOGO will be added when available); (f) instructions on how to load and unload the program; (g) answers to homework assignments; and (h) answers to tests.

An outline for the first 28 LOGO lessons was written and is given in Table 11. Each lesson takes about 45 minutes for the average student.

2. Implementation

The classroom situation. A PDP-8i computer was to serve as a station monitor at Woodrow Wilson High School. This computer, however, was not delivered on schedule, and the projected shipment date is now April 18. The following schedule was used in working with the six classes of 15 students each.

TABLE 10

Outline of SIMPER Lessons, Lessons 1-38

Lesson	Description
1	Use of control commands. How to use the teaching program.
2	Instructions 'FIX' and 'STOR.'
3	Instructions 'BEGIN,' 'END,' and 'PUT.'
4	Practice.
5	The instruction 'ADD.'
6	The instruction 'LOAD.'
7	Instructions 'MUL,' 'SUB,' 'DIV,' and 'SOP.'
8	Practice.
9	Signing on to SIMPER, learning to write programs directly in SIMPER.
10	The instruction 'GET.'
11	Writing programs to solve word problems.
12	Inputting negative numbers.
13	Using more than one arithmetic operation in a program.
14	Review.
15	Studying equivalent solutions to problems.
16	Practice writing programs directly in SIMPER.
17	Use of register B.
18	How 'DIV' uses two registers.
19	Comparing numbers.
20	The instruction 'CMP.'
21	Practice using 'CMP.'
22	Introducing the jump command, 'JMP.'
23	Practice using 'JMP.'
24	Reading other people's programs.
25	Practice, emphasis on 'CMP' and 'JMP.'
26	'JMP' and 0: how to make sure a jump will always occur.
27	Review.
28	The instruction 'NAME,' used to label locations.
29	More about 'NAME.'
30	Writing programs to check the divisibility of a number.
31	Practice, emphasis on 'NAME' and divisibility.
32	Review.
33	Counters: making a program check how many times you've performed a given operation.
34	Loops: using a counter.
35	Practice, emphasis on loops.
36	Writing problems involving loops to solve problems.
37	Specifying two conditions in a program.
38	Practice and review.

TABLE 11

Outline of LOGO Lessons, Lessons 51 to 78

(The First 28 Lessons of the Course.)

Lesson	Description
51	Defining LOGO words and sentences; an introduction to use of quotation marks in LOGO; the instruction 'PRINT.'
52	The instructions 'WORD,' 'SENTENCE.'
53	The instructions 'FIRST,' 'BUTFIRST.'
54	The instructions 'LAST,' 'BUTLAST.'
55	Practice.
56	Using two instructions.
57	Using more than two instructions.
58	Practice.
59	Signing on to LOGO.
60	Review.
61	The instructions 'SUM,' 'TIMES,' 'DIFFERENCE,' and 'QUOTIENT.'
62	Inputting negative numbers.
63	The instruction 'CALL.'
64	Applications of 'CALL.'
65	Further applications of 'CALL.'
66	The instructions 'IS,' 'IF YES,' 'IF NO.'
67	The instructions 'WORD?,' 'SENTENCE?,' and 'NUMBER?.'
68	The instruction 'IF.'
69	Practice.
70	Introduction to writing procedures. The instructions 'TO,' 'END.'
71	Instructions for editing procedures.
72	The instruction 'GO.'
73	The instruction 'RETURN.'
74	Practice.
75	Recursive procedures.
76	The instructions 'TRACE,' 'UNTRACE.'
77	Practice.
78	Review.

(a) Feb. 5 to 7: Teachers taught flow-charting, discussed what a computer is, what a program is.

(b) Feb. 10 to 21: Mrs. Sears taught each class, introducing topics covered in the first seven lessons.

(c) Feb. 24 to Mar. 28: The classes ran on six teletypes through Collins data sets. A high rate of absenteeism and bouts of flu meant most students ran on-line for a half-period each day. Mrs. Sears and the teachers provided work sheets for the students not working on-line.

(d) March 31: More Collins data sets were installed, so that 12 teletypes will be available when the students return from spring vacation on April 7.

As students left school, students on a waiting list entered the classes. About six students are taking the course during their lunch hour without receiving credit. An adult education class is also using the course from 7:00 to 9:00 p.m. on Tuesday and Thursday evenings.

Students are progressing at varying rates. As of March 31, the slowest student was on Lesson 8 and the fastest on Lesson 22.

Programming. Mr. Paul Lorton has continued to debug and refine the program that controls the curriculum lessons. This program is now ready to handle LOGO lessons as well as SIMPER lessons. Mr. John Slimick completed a Stanford version of LOGO,[5] and this version is being incorporated into Mr. Lorton's program.

Miss Lucy Darley, who recently joined the staff half-time, began work on writing the programs that will make the course available on the PDP-10 computer in the fall.

F. Stanford PDP-1/PDP-10 System

1. Hardware

All six of the Ampex core memories are now interfaced and operational on the PDP-10, giving a total of 192k words. The PDP-10 CPU, the disk channels, and the audio multiplexer are connected to all six memories. The PDP-1 and the high-speed data line controller have not yet been extended to the new units.

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[5] Developed by and used with the permission of Bolt, Beranek, and Newman, Inc.

The second 2314 disk file and its interface hardware are operational. Each disk is connected to an independent data channel, allowing simultaneous data transfers to both units. The two channels, while logically independent, share a common interface to the Ampex core memory.

Two 2401 Model-IV magnetic-tape drives and a 2803 tape control unit were delivered by IBM. Installation of these units was nearing completion at the close of the reporting period. The tape control will be connected to one of the existing disk data channels and will require no additional interface hardware. The principal feature of these drives is very high density recording (1600 Bytes per inch), which will minimize the expense of storage media for long-term storage of the large volume of real-time data generated by the instructional programs.

The PDP-8/I system ordered for the San Francisco project was not ready for the scheduled installation date, and DEC was unable to assure delivery at any reasonable future date. Therefore, an order was placed for a twelve-channel line multiplexer system from Collins Radio to meet this critical situation. This system is similar to that being used for the Washington, D.C. terminals. The equipment was received and installed and has been in service through most of the reporting period. The PDP-8/I remains on order and eventually will replace the Collins units. After the replacement by the PDP-8/I, the Laboratory plans to keep the Collins equipment on active stand-by status to meet similar emergencies in the future and to facilitate short-term remote demonstrations with a larger number of terminals then is now feasible.

Early in the quarter, the Laboratory suffered a number of severe power failures that not only prevented operation during the power outages, but also caused some damage to the electronic circuits in the computer systems. Most of these failures were caused by the series of winter storms which afflicted most of California, but one was due to a burned-out cable in the main underground power line supplying the Stanford Computation Center and the IMSSS Laboratory. Several steps were taken in an attempt to minimize future effects of this type of trouble. Voltage-regulating transformers were ordered and installed in the power supply circuits of each of the Ampex memory units, since core memory systems are the most susceptible to damage or transient data errors. The Laboratory and the Stanford Computation Center currently are considering the joint purchase of emergency generator equipment which would smooth out most power transients, in addition to supplying an alternate source of power in event of complete failure on the public utility lines.

A wide variety of solid and intermittent failures in the memory system prevented reliable operation of the PDP-10 during a significant portion of the reporting period. The troubles were finally eliminated after an exhaustive general shake-down of the entire memory system. Failures were traced to faulty circuit cards in both the Ampex units and the interface logic, and broken wires, loose mechanical connections, and cold-soldered joints in numerous areas. Minor design modifications were implemented in the interface logic. The core memory units, interface logic, and cables connecting the other major components of the system are now quite solid, and the occasional failure of a circuit card is relatively easy to isolate.

2. Software and Operations

Modifications were made to the PDP-1 and PDP-8 systems to allow the use of a greater number of local teletypes on the Stanford PDP-8. Changes were required on all three machines in the Laboratory to implement the PDP-8 console teletype intercom mechanism. Operators at the remote PDP-8's now can communicate with the Stanford Laboratory during normal operation of the instructional network. Some of the present features were available previously, but have been inactive since the transfer of the high-speed line interfaces to the PDP-10.

The great majority of software effort during the period was directed to the PDP-10 system and various support programs for this system. General development and debugging work improved the operation of the digitized audio unit and the high-speed data line interface. System routines were modified and bare-machine programs were developed to facilitate more efficient and reliable use of the 2314 disk files. Extensive changes were required to allow simultaneous operation of the two disk channels. Some changes were made in the DEC time-sharing system to increase its utility in the present configuration.

II. Activities Planned for the Next Reporting Period

A. Drill-and-practice Mathematics Program

The work of revising and editing the strands program will continue as will the work on the problem-solving program which will include the selection and writing of suitable problem items.

The operation of the drill-and-practice program which was shifted to the PDP-10 will be checked thoroughly and debugged.

Work will continue on the revision of the Tennessee A. and I. mathematics program.

An increased emphasis will be placed on working with deaf and handicapped children. Also, efforts to work with a larger number of adults in basic education programs will be made.

B. Drill-and-practice Reading Program

When the digital-audio processes have been developed sufficiently to allow maximum capacity, the recording of additional words and messages will be completed to bring the directory up to the 6,000 message goal. Continued efforts will be made to complete Strand 5 which deals with word meanings and to code it for use. Cooperation with the Ravenswood City School District will be foremost in our efforts this quarter to facilitate the operational aspects of the reading program. Demonstrations and workshops will be scheduled for teachers and proctors.

Programs for efficient analysis and retrieval of reading data will be written by the research staff.

C. Second-year Russian Program

The second-year course will be completed. It is hoped that the PDP-10 system will be sufficiently reliable to permit (a) the use of computer-generated audio, at least on an experimental basis; and (b) the generation of individualized remedial lessons based on analyses of the student's previous performance.

D. Computer-assisted Instruction in Programming: AID

Lesson writing, coding, and debugging will continue during the next three months. Early lessons will be revised and new lessons will be written.

Work on the time-sharing version of the instructional system will commence and modifications will be made in the coding language and in the lesson preprocessor.

E. Computer-assisted Instruction in Programming: SIMPER and LOGO

Next quarter, 28 LOGO lessons will be written, coded, and debugged. A homework assignment will be prepared for each lesson. Tests and extra-credit problems will also be developed. A detailed analysis of lessons on the basis of teachers' and students' comments will be made preparatory to revising the materials over the summer.

Programming for the PDP-10 computer will continue. One of the first tasks will be to get SIMPER and LOGO running on the PDP-10.

F. Stanford PDP-1/PDP-10 System

Software development and final hardware check-out on the IBM magnetic tape drives should be completed early in the period. Hardware and software interfacing should be completed for the Teletype Inktronic printer, whose delivery is expected early in the quarter.

A new form of information encoding will be applied to the data transmitted over the high-speed lines to the remote PDP-8 systems. This new coding scheme will enable a larger number of terminals to operate from each line.

General development work will proceed on the PDP-10 time-sharing system, and more functions that are now performed by the PDP-1 will be transferred to the PDP-10 system.

III. Dissemination

A. Publications

Atkinson, R. C. First-letter clues in the retrieval of proper names from long-term memory. Psychological Reports, 1968, 23, 851-866. (with R. H. Hopkins)

Atkinson, R. C. Processing time as influenced by the number of elements in the visual display. Technical Report No. 140, March 14, 1969, Stanford University, Institute for Mathematical Studies in the Social Sciences. (with J. E. Holmgren and J. F. Juola)

Atkinson, R. C. Computer-assisted instruction in initial reading: The Stanford Project. Teacher's Manual. Stanford: Institute for Mathematical Studies in the Social Sciences, 1969.

Jerman, M., and Suppes, P. A workshop on computer-assisted instruction in elementary mathematics. The Arithmetic Teacher, 1969, 193-197.

Suppes, P. Can there be a normative philosophy of education? In G. L. Newsome, Jr. (Ed.), Philosophy of education 1968: Proceedings of the twenty-fourth annual meeting of the Philosophy of Education Society--Santa Monica, April 7-10, 1968. Edwardsville, Illinois: Studies in Philosophy and Education, Southern Illinois University, 1968. Pp. 1-12.

Suppes, P., and Jerman, M. Computer-assisted instruction at Stanford. Educational Technology, January 1969, 22-24.

B. Lectures

Atkinson, R. C. Instruction under computer control. Invited lecture presented at the California State Psychological Association meetings, Newport Beach, California, February 1, 1969.

Atkinson, R. C. Human memory: And its control processes. Lecture presented to Department of Psychology Colloquium, University of Washington, Seattle, March 6, 1969.

Atkinson, R. C. Theory of instruction. Lecture presented at the Conference on Instructional Strategies, The Smithsonians Institution Conference Center, Elkridge, Maryland, March 19, 1969.

Atkinson, R. C. The theory of human memory and its applications. Lecture presented to the Veterans' Administration Hospital, Palo Alto, California, March 27, 1969.

Jerman, M. The Stanford CAI project. A presentation of the Stanford Program to Dr. Max Rafferty, State Superintendent of Instruction and curriculum specialists, Sacramento, California, January 8, 1969.

Jerman, M. Workshop in CAI. New York City Teachers, New York, January 23, 24, 1969.

Jerman, M. Workshop in computer-assisted instruction. Teachers, Franklin County Schools, Columbus, Ohio, January 29, 30, 1969.

Jerman, M. Evaluation of progress in CAI. Lecture presented to Seminar, Los Angeles City Administrative Staff, Los Angeles, California, February 14, 1969.

Jerman, M. Computer-assisted instruction. Lecture presented to students in extension course in computer-assisted instruction, University of California, Santa Cruz, Palo Alto, California, March 14, 1969.

Jerman, M. Computer-assisted instruction. Lecture presented at Seminar, University of Dayton, Dayton, Ohio, March 26, 1969.

Morningstar, M. Four programs in computer-assisted instruction. Lecture presented to a graduate student seminar, New Mexico State University, Las Cruces, New Mexico, March 7, 1969.

Morningstar, M. Difficulties encountered in developing curriculum and software for computer-assisted instruction purposes. Lecture presented to faculty and administrative informal seminar, Teacher Education, Behavioral and Social Sciences, New Mexico State University, Las Cruces, New Mexico, March 7, 1969.

Morningstar, M. The future of computer-assisted instruction within the instructional act. The Claude C. Dove Lecture presented at New Mexico State University, Las Cruces, New Mexico, March 7, 1969.

Smith, R. Computer-generated dialogue for instruction. Lecture presented to School of Education, University of California, Santa Barbara, January 22, 1969.

Smith, R. The Stanford logic program. Lecture presented at the AERA Presession, The computer and natural language, Los Angeles, February 3, 1969.

Smith, R. Computer-generated dialogue for instruction. Lecture presented to School of Education colloquium, University of Washington, Seattle, Washington, March 5, 1969.

Smith, R. Computer controls of logic learning studies. Lecture presented to Department of Psychology Colloquium, Florida State University, Tallahassee, Florida, March 13, 1969.

Suppes, P. A mini-step approach to elementary mathematics. Lecture presented at meeting sponsored by the Greater San Diego Mathematics Council, San Diego, California, January 9, 1969.

Suppes, P. Stimulus-response theory of language learning. Lecture presented at Psychology Colloquium at the University of California, Santa Barbara, January 14, 1969.

Suppes, P. The logic of intuitive geometry. Lecture presented at meeting of American Mathematical Society, New Orleans, Louisiana, January 24, 1969.

Suppes, P. The dimensions of educational research. Lecture presented at AERA meeting, Los Angeles, California, February 5, 1969.

Suppes, P. Stimulus-response theory of finite automata. Lecture presented to Department of Electrical Engineering and Computer Science at University of California, Berkeley, February 20, 1969.

Suppes, P. Stimulus-response theory of finite automata and language learning. Lecture presented at Rockefeller University, New York, February 28, 1969.

Suppes, P. Computer-assisted instruction: Current operations and future prospects. Annual Basterfield Lecture at University of Saskatchewan, Regina Campus, March 24, 1969.

Suppes, P. Mathematical models of learning as applied to computer-assisted instruction. Lecture presented to Division of Natural Sciences and Mathematics, University of Saskatchewan, Regina, March 25, 1969.

Suppes, P. Foundations of measurement. Lecture presented to Department of Psychology, University of Illinois, Urbana, Illinois, March 26, 1969.

Suppes P. The structure of scientific theories and the analysis of data. Lecture presented at symposium on the Structure of Scientific Theories, University of Illinois, Urbana, Illinois, March 27, 1969.

CAI NEWSLETTER

INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES
STANFORD UNIVERSITY

Vol I., No. 1 November 1968

Beginning with this issue, a newsletter will be distributed periodically to all schools and teachers participating in various CAI programs sponsored by the Institute. We hope this newsletter stimulates communication between people at Stanford and teachers and administrators taking part in the project. We want this newsletter to provide an avenue for exchange of ideas, problems, and everyday happenings between teachers and administrators.

New Schools

Welcome to all schools new to the program this year. Ten elementary schools of the Ravenswood School District in Palo Alto, California joined the arithmetic and reading programs. As the programs get underway, fifty teletypes will be devoted to arithmetic and forty to reading. A description of the reading program will be a feature article in a future newsletter.

Several new schools were added in both Kentucky and Mississippi--32 teletypes now run in Eastern Kentucky and 60 in Mississippi.

Tennessee A. and I. State University is also new to the project this year. A special series of blocks have been prepared for use with their Math 111 course. Students will spend 20 minutes each day outside class on drill-and-practice lessons in arithmetic and algebra on 20 teletype terminals located in a newly constructed CAI laboratory on campus.

We have completed arrangements to install three teletypes in Kendall School for the Deaf in Washington, D. C. This program should prove to be both exciting and challenging and will present an opportunity to demonstrate the versatility of an instructional CAI approach in this new application.

A single terminal is located in La Salle, Illinois. Mr. Peter Miller, publisher of the Daily News-Tribune there is sponsor of the demonstration project.

School of the Month

Featured in this first issue are Fremont Hills Elementary School in the Palo Alto Unified School District in California, and Mrs. Christiane Creighton, a third-grade teacher.

In addition to teaching her own class of 29 students, Mrs. Creighton supervises the fifth- and sixth-grade students taking the logic program. All of this, mind you, takes place on a single teletype located in a small closet at the back of her classroom. Not only has she successfully supervised the logic students who come in throughout the day, but she has managed to run

nearly all of her own third graders on the teletype each day!

If Mrs. Creighton's remarkable energy and enthusiasm continue, her classes will show significant gains for a second year.

Ravenswood

In April, 1968, John A. Minor, Superintendent of the Ravenswood City School District in East Palo Alto, California, announced the appointment of William S. Rybensky as Director of the Title III: Stanford-Ravenswood CAI Project. Thus, the district began its fourth year of CAI in cooperation with the Institute. On October 16, Mrs. Neva Spillers' primary-level class at the Brentwood School began the first district use of the drill-and-practice program in mathematics using three temporary acoustic-coupled teletypewriters (TTYs).

When full-scale operation begins, 8 para-professional proctors hired from within the district will monitor the 8 elementary-school clusters. The teletype machines assigned to each school are to be put in special temporary classrooms now under construction. Approximately 3,000 children per day are expected to take lessons on the system. From the beginning of the 1968-69 school year, teachers, proctors, and administrators have been participating in a cooperative IMSSS-Ravenswood inservice workshop.

In the Classroom

You can't stop it.
Once a student starts a lesson, the lesson continues, as far as the computer is concerned, even though the teletype is turned off. What happens is that the computer continues to record time-outs for each problem until the lesson is ended. Therefore, it is better for the student to finish any lesson he has begun.

Handbooks will soon be finished.
The many requests for teacher handbooks will be honored as the final touches are put on the new program. The handbook is a revision of last year's handbook describing the new strands and problem-solving programs.

Each teacher and administrator will receive a copy as soon as the handbooks are completed.

Daily reports.
The pretest and posttest scores are distinguished by the next to the last number on the daily reports. The pretest has a zero (B304004) and the posttest has a 6 (B304063). The last number designates the level of the last lesson completed by the student.

Teletype machine I.D. number.
To determine the number of the teletype machine you are trying to check, just type "Control" "F"; that is, hold down the Control key and type F. The teletype will then type out its number. It helps if you can tell the serviceman exactly which machine is having trouble.

Demo numbers.
The demonstration numbers are different each month. If you plan to have an open house or to give a demonstration to a group, be sure to see what the current names are. Each time they are changed, someone in your area will be notified.

Evaluation of the Mississippi CAI Project

To evaluate the effectiveness of the drill-and-practice program for 1967-68, the arithmetic portion of the Stanford Achievement Test (SAT) was administered to both experimental and control classes. The tests were administered in October and again in

May to students in grades 2 through 6; students in grade 1 took the tests in February and May. Twelve different schools in Mississippi participated in the testing program. Eight of these schools included both experimental and control students, three included only experimental students, and one included only control students. Within the experimental group, from one to ten classes were tested at each grade level; within the control group, from two to six classes were tested at each grade level.

The difference between the posttests and pretest grade placement on the computation section of the SAT was our measure of learning for the school year. The difference in learning between the experimental students and the control students was then examined for each grade level. The average change in grade placement for each grade for each of the two groups and the t-values are:

	Posttest-Pretest			
Grade	Experimental	Control	t	df
1	1.14	.26	3.69*	112
2	1.42	.84	5.23*	77
3	2.03	1.26	4.64*	76
4	1.10	.69	2.63*	131
5	1.37	.90	3.43*	215
6	1.72	1.13	5.18*	433

*$p < .01$ The t-value is a standardized score. The values shown indicate that the chances of getting a gain of the size shown by chance, are less than 1 in 100.

The difference between the experimental group and the control group is largest in grade 1, where, in only 3 months, average increase in grade placement for experimental students was 1.14 as compared to .26 for the control students. Although the differences are significant, the effect of the CAI program was least for the fourth and fifth graders. There is no doubt, however, that the drill-and-practice program as indicated by this classical statistical evaluation was quite successful.

This Month's Operation

Twenty-nine schools totaling 143 classes were enrolled in the CAI network as of Monday, October 28. The following table shows the distribution of classes at each grade level in each school according to our records. The grade level shown indicates the student's grade level in school. In some cases, particularly junior high, the students are not working at grade level in the CAI program.

From October 9 to October 28, a total of 7,737 arithmetic and logic lessons were given to students in the classes shown in the table.

Some of the classes are well into their sixth block of lessons. Others have barely started. We expect that the average number of lessons given daily will soon exceed the number of lessons taken by all schools to date.

Letters to the Editor

This space will be reserved in each newsletter for letters from teachers and administrators in project schools. If you have questions, experiences to share, or problems to share, let us hear about them.

Send your letters to:
Max Jerman
Title III Coordinator
The Stanford CAI Program
Stanford University
Cedar Hall A-3
Stanford, California 94305

Whether you have questions or not, please send by return mail, a post card with your name, address,

and zip code on it. We wish to send all future issues of the newsletter to each person individually by mail. Your promptness in helping us complete our mailing list will be appreciated.

TABLE 1

Distribution of Classes at each Grade Level at each School

as of Monday, October 28, 1968

Location	Grade Level 1	2	3	4	5	6	7	8	9	Total
California										
Walter Hays				3	3	4				10
Jordan Jr. High							1	1		2
Fremont Hills			1							1
Oak Knoll	2	2	3							7
Peter Burnett Jr. High									8	8
Brentwood			1							1
Kentucky										
Breckinridge	1	1	1	1	2					6
Elliottville	1	1	1	1	1					5
Paintsville				3						3
Upper Tygart		1	1	1	1	2				6
Sandy Hook			2		2					2
Pikeville					2	1				3
Louisa			1	1	1					3
Flat Gap			2	1	1					4
Holy Family						1		1	1	3
Mississippi										
Universal	1	2	2	2	2	1				10
Otken		3	3	3	3	3				15
Alpha Center	1	1								2
Kennedy		1	1	1	1	1				5
Netterville		1	1	2	1	1				6
Summit	1	1	1	1	1	1				6
Taggart		2	1	1	2	1				7
Westbrook		4	2	3	2	3				14
Franklin					1	2				3
Magnolia			2							2
Fernwood					1					1
Lillie M. Bryant									1	1
Denman Jr. High									3	3
Eva Gordon				1		1				2
Totals	7	20	26	25	28	22	1	2	13	144